THE USE OF NATURAL ZEOLITE AS an ADDITIVES In WARM MIX ASPHALT WITH POLYMER MODIFIED ASPHALT BINDER

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THE USE OF NATURAL ZEOLITE AS an ADDITIVES In WARM MIX ASPHALT WITH POLYMER MODIFIED ASPHALT BINDER

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1. Introduction

1.1. Background

Polymer modified asphalt concrete mixture is used as a mixture to increase the durability of pavement to various damage such as permanent deformation, cracking due to temperature changes, fatigue [1]. But unfortunately polymer modified asphalt mixing process for long time is using the method of Hot Mix Asphalt. Hot asphalt mixture using a polymer modified asphalt intended to increase resistance to a variety of damage, requires a fairly high temperature mixing in Asphalt Mixing Plant / AMP that higher around 175°C [2]. Mixing temperature is the temperature at which bitumen has a viscosity of 170 ± 20 cSt, while the viscosity of the asphalt compaction temperatures between 280 ± 30cSt [3]. The high temperature of mixing and compaction temperatures in the process of making asphalt mixture, so much fuel is used, the exhaust emissions are large and require high cost [4].

Some countries have developed technology asphalt mixture using temperature mixing and compaction temperatures lower than Hot Mix Asphalt, known as Warm Mix Asphalt / WMA. Warm Mix Asphalt technology has become a key technology in the construction of roads in the United States and the world [8]. WMA is an environmentally friendly technology by adding an additive to the asphalt mixture. Types of additives that have been widely used and developed for Warm Mix Asphalt is the use of synthetic zeolites with various trademarks such as Aspha-min (R), Sasobit (R) and Advera (R). Warm Mix Asphalt, produced in AMP and compacted in the field while maintaining the required workability so it can be spread and compacted well [5].

Additives used in this study are derived from natural zeolites Bayat, Central Java, Indonesia with mineral type modernit. Natural zeolite serves as an additive in asphalt concrete mixtures modified polymers, by utilizing the water it contains, can increase the volume of asphalt during the mixing process and compaction [7]. Before it is used as an additive in asphalt mixtures is conducted prior processing of natural zeolite using chemical activation method. Activation Chemistry, aims to clean up the surface pores, removing impurities and compounds rearrange the location of the atoms are interchangeable, making the size of the zeolite pores become larger so that it can hold and release water quickly without damaging the structure, increasing the viscosity of bitumen at mixing temperature lower. This study aims to obtain a polymer modified asphalt mixture with natural zeolite additives that can be mixed and compacted using warm mix asphalt technology.

1.2. Objectives

The main objectives of this research include: (1) assess the natural zeolite processing method that can be used as an additive in asphalt concrete mixtures modified polymers that are processed using warm mix asphalt technology (2) assess levels of zeolite to lower temperature optimum mixing and compaction on asphalt concrete mixture that meet the specifications of polymer modified Marshall (3) assess the temperature drop in the mixing and compaction temperatures on the warm asphalt mixtures using polymer modified asphalt mixtures with additives of natural zeolite.

2. Context And Review Of Literatur

2.1. Polymer Modified Asphalt

Polymer modified asphalt is used to increase the durability of asphalt to temperature changes with increasing stiffness binder / binder at elevated temperatures and reduced stiffness at low temperatures at the same time [13]. Polymer as an material added (modifier) in asphalt concrete mixtures modification is to increase the stiffness at high temperatures, to reduce rutting and at the same time reducing the stiffness at low temperatures to reduce brittleness and cracking [14]. Classification of polymers [2] [refer with: Table.1].

Table. 1 Classification of Polymers

Polymer Type	Common name	Needs for commpation
SBS (Styrene Butadiene Styrene)	Thermoplastik Rubber	Hot Mix, filling Cracks
EVA (Ethylene Vinyl Acetate)	Thermoplastic	Durability of flows, Seal, Crack
Polyethylene, Polypropylene	Thermoplastic	Durability against Flow
SBR (Styrene Butadiene Rubber)	Synthetic Rubber / Elastomer	Durability against cracks, grooves
Natural Rubber	Rubber	Durability against cracks, grooves

2.2. Marshall Calculation

a. Density

Density is the weight of the mixture, measured per unit volume. The mixture has a high density values indicate a mixed ability withstand traffic loads better and have a high kekedapan to water and air. Density value is calculated [refer with: Eq. 1, Eq. 2].

$$G_{mb} = c/f \tag{1}$$

$$f = d - e \tag{2}$$

Specification:

c = Weight before soaking water (grams)
d = Weight in the saturated state (g)
E = Weight in water (grams)
f = The contents of the test specimen (g / cc)

b. Voids in the Mineral Aggregate (VMA)

Voids in the Mineral Aggregate is the space between the aggregate particles in an asphalt pavement, including air voids and effective asphalt volume (excluding the volume of absorbed asphalt aggregate). The calculation of VMA against the total weight of the mixture [refer with: Eq. 3].

$$\mathrm{VMA} = 100 - \left[\frac{G_{mb} \,x\, P_s}{G_{sb}}\right] \tag{3}$$

Specification:

VMA = Cavity between the mineral aggregate, percent of bulk volume
Gsb = Bulk density of aggregate
Gmb = Bulk density of solid mixtures
Ps = The aggregate level, percent of total mix

VMA calculations to the total weight of aggregate [refer with: Eq. 4]

$$\mathrm{VMA} = 100 - \frac{G_{mb}}{G_{sb}} x \frac{100}{100+P_b} x100 \tag{4}$$

Specification:

Pb	= Bitumen content, percent of total mix
Gsb	= Bulk density of aggregate
Gmb	= Bulk density of solid mixtures

c. Voids in the Mix (VIM)

Voids in the Mix (VIM) consists of the air space between the aggregate particles covered in asphalt after compacted. VIM is tantamount to porosity and its value will be reduced if the mix asphalt content increases, due to the mixture in the cavity will be filled with asphalt. VIM is influenced by temperature compaction, gradation, asphalt content and compaction energy. VIM controlled as it relates to the permeability. Voids in the mixture used for space shifting aggregate grains when the compaction by traffic load, or space for asphalt when the asphalt melts when the temperature increases. Percent volume of air in the cavity can be determined [refer with: Eq. 5].

$$\mathrm{VIM} = 100\mathrm{x}\frac{G_{mm} - G_{mb}}{G_{mm}} \tag{5}$$

Specification:

VIM	= Air cavity solid mixture, percent of total mix
Gmb	= Bulk density of solid mixtures
Gmm	= Maximum density mixture, zero air voids

d. Voids Filled Bitumen (VFB)

Voids Filled Bitumen (VFB) is the percentage of voids, which are among the aggregate particles (VMB) which is filled by asphalt, does not include asphalt absorbed by the aggregate. VFB values that are too high can lead to rise to the surface when the asphalt pavement temperature high while VFB is too low resulting mixture is porous and easily oxidized. VFB formula [refer with: Eq. 6].

$$\mathrm{VFB} = 100\,\frac{(\mathrm{VMA} - \mathrm{VIM})}{\mathrm{VMA}} \tag{6}$$

e. Stability

Stability is the ability of the hard layers, to withstand deformation due to traffic loads that work on it without changing its form remains as wave (wash boarding) and groove (rutting). Stability value, which is required is more than 800 kg. Pavement layers with stability values of less than 800 kg will be susceptible to rutting, because the pavement is soft so it is less able to support the load. Conversely, if the stability of the pavement is too high then the pavement will be easy to crack because of the nature of rigid pavement. Corrected value of stability [refer with: Eq. 7].

$$\mathrm{S} = \mathrm{q} \times \mathrm{C} \times \mathrm{k} \times 0{,}454 \tag{7}$$

Specification:

S	= Value Stability Corrected (Kg)
q	= Reading Marshall Stability In Dial Tool (lb).
k	= Calibration Factor
C	= Thickness Calibration Factor
0.454	= Conversion from lb to kg Load

k. Flow

Flow is the amount of vertical deformation of the specimen occurs at the beginning of loading so that the stability decreases, which indicates the amount of deformation that occurs in the pavement layers due to the weight it receives. Deformation is closely related to other properties such as Marshall stability, VIM and VFB.

l. Marshall Quotient (MQ)

To determine the stiffness of asphalt concrete mixtures to be analyzed to find the value of Marshall Quotient (MQ). MQ value is less than 300 kg / mm to mix AC modification, resulting in pavement prone to washboarding, rutting and bleeding. Marshall Quotient (MQ), is the quotient of the stability divided (flow), [refer with: Eq. 8].

$$MQ = \frac{S}{F} \tag{8}$$

Specification:

MQ = Marshall Quotient, kg / mm
S = Marshall Stability, kg
F = Flow, mm

3. Experimental Work

3.1. Materials and Mix Proportion.

This warm mix asphalt research, using additives natural zeolite mineral modernit sourced Bayat, Central Java, Indonesia, powder form and aggregate used was from Subang, West Java, Indonesia, with the combined aggregate gradation to wear layers as well as elastomeric polymer bitumen which is used the type of asphalt Starbit E-55. Elastomeric polymer modified asphalt based on its ability to be more resistant to deformation after receiving a load on the surface and will stretch the surface and returns to its original shape after the load is lost. Natural zeolites are used because it is cheap and Indonesia is one of countries with the largest deposits of natural zeolites [11]. Before use, natural zeolite first processed using the method of chemical activation and physical activation. The purpose of the chemical and physical activation method is to increase the water content of the natural zeolite innate, by 3.7%. The difference, chemical activation using chemicals, whereas the purpose of physical activation, as well as to increase the water content of zeolite, but with the heating. The results of the second activation will be selected based on the activities that produce moisture content approaching the synthesis of zeolite water content (± 20%). The flow of research [refer with: Fig. 1].

3.2.Research Flow Chart.

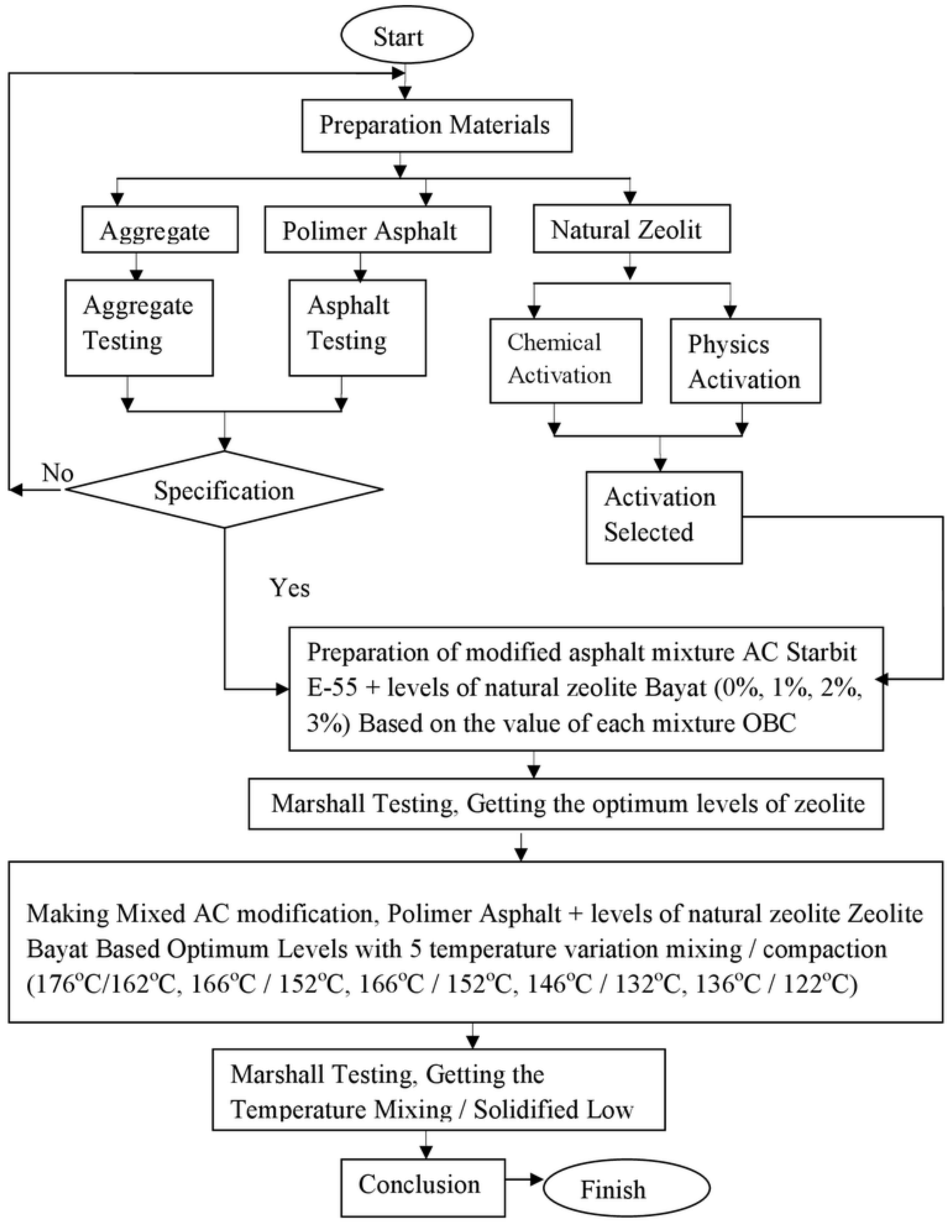

Figure. 1 Flowchart Research

4. Results and Discussion

4.1. Aggregate testing

Results of testing coarse and fine aggregate can be seen in Table [refer with: Table 2, Table 3] as well as screening analysis can be seen in Table [refer with: Table 4 and Fig.2]. Based on the specifications of Bina Marga / Highways (2010), the aggregate test results meet the specifications [3].

Table. 2 Results of Coarse Aggregate Quality Testing

No	Testing Type	Methods Type	Result	Specification	Unit
1.	Abrasion	SNI 03-2417-2008	17,5	≤ 40	%
2.	Bulk Specific Gravity	SNI 03-1969-2008	2,647	> 2,5	-
3.	Saturated Surface Dry	&	2,688	2,5	-
4.	Apparent Specific Gravity	SNI 03-1970-2008	2,760	< 3	-
5.	Absorption	SNI 03-1969 -2008	1,543	≤ 3	%
6.	Angularitas Coarse Aggregate	ASTM D 4791-2005	99,9/99	≥ 95/90	%
7.	Particles Flat and Oval	ASTM D 4791-2005	1,0	≤ 10	%
8.	Weathering	SNI 03-3407-1994	0,3	≤ 12	%
9.	Escaped Sieve No. 200	SNI 03-4142-1996	0,47	≤ 1	

Table. 3 Results of Fine Aggregate Quality Testing

No	Testing Type	Methods Type	Result	Specification	Unit
1.	Sand equivalent	SNI 03-4428-1997	61,0	≥ 60	%
2.	Bulk Specific Gravity	SNI 03-1969-2008	2,658	> 2,5	-
3.	Saturated Surface Dry	&	2,691	2,5	-
4.	Apparent Specific Gravity	SNI 03-1970-2008	2,748	< 3	-
5.	Absorption	SNI 03-1969 -2008	1,235	≤ 3	%
6.	Fine Aggregate Angularitas	SNI 03-6877-2002	48,50	≥ 45	%
7.	Weathering	SNI 03-3407-1994	1,8	≤ 12	%
8.	Clumps of clay	SNI 03-4141-1996	0,40	≤ 1	%

Table. 4 Results of Testing Sieve Analysis

Testing Type	Methode Type	Coarse Aggregate	Fine Aggregate	Unit
Sieving	ASTM C 136:2012			
3/4" (19,1 mm)	-	100.0	-	% escapes
1/2" (12,5 mm)	-	57.2	-	% escapes
3/8" (9,5 mm)	-	16.9	100,0	% escapes
# 4 (4,76 mm)	-	6.4	99,3	% escapes
# 8 (2,36 mm)	-	3.6	79,1	% escapes
# 16 (1,18 mm)	-	1.9	54,0	% escapes
# 30 (0,60 mm)	-	1.3	36,5	% escapes
# 50 (0,30 mm)	-	1.0	23,7	% escapes
# 100 (0,149 mm)	-	0.7	14,1	% escapes
# 200 (0,075 mm)	-	0.5	9,9	% escapes

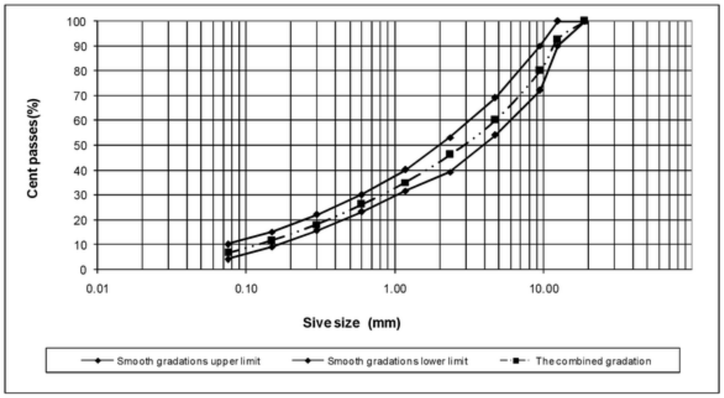

Figure. 2 Gradient Combined Mixed Graph

4.2. Polymer Modified Asphalt Testing

Elastomeric polymer bitumen testing results can be seen Table [refer with: Table. 5]. Based on test results elastomeric polymer bitumen asphalt meets the specifications [3].

Table. 5 Results of Testing Quality Asphalt Polymer Elastomer

No.	Testing Type	Methods Type	Result	Specification
1.	Penetration at 25 ° C, 100 g, 5 seconds	SNI 2456 : 2011	61	50 – 70
2.	Viscosity at 135oC	SNI 06-6441-2000	818	≤2000
3.	Softening point (oC)	SNI 2434 : 2011	53,5	-
4.	Ductility at 25 ° C, 5 cm / min (cm)	SNI 2432 : 2011	> 140	≥100
5.	Flash point (COC) (oC)	SNI 2433 : 2011	332	≥232
6.	Solubility in C2HCl3 (%)	SNI 06-2438-1991	99,8663	Min. 99
7.	density	SNI 2441 : 2011	1,036	≥1,0
8.	Losing weight (TFOT)	SNI 06-2440-1991	0,0145	≤2,2
9.	The difference in softening point (oC)	ASTM D 5976 part. 6.1	0,2	≤0,8
10.	Penetration after TFOT (%)	SNI 2456 : 2011	85,2	≥54
11.	Ductility after TFOT (cm)	SNI 2432 : 2011	> 140	≥50
12.	Mixing temperature (oC)	ASSHTO-72-1990	173 – 179	
13.	Solidification temperature (oC)	ASSHTO-72-1990	159 - 165	≥45

4.3. Zeolit Calculation

Test results using the method of activation of natural zeolite chemistry and physics can be seen in Figure [refer with: Fig. 3]. Referring to the results of activation, chemical activation results obtained provide the water content of the natural zeolite was 18.99% greater than the result of activation of physics that just gives the water content of the natural zeolite was 9.64%. So, which is used as an additive in this study were processed using natural zeolite chemical activation.

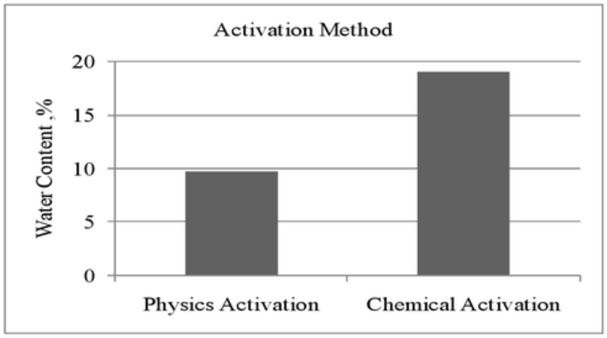

Figure. 3 Effect of Activation Method Against Moisture Absorption In Zeolites

4.4. Marshall Calculation

The test results are divided into three namely Marshall Marshall testing to obtain optimum bitumen content, Marshall testing to obtain optimum levels of zeolite that can be used as an additive mixture of polymer modified asphalt concrete [refer with: Table. 6] and Marshall test to obtain the temperature of the mixing / compaction temperature in a mixture of polymer modified asphalt concrete additives with natural zeolite using Warm Mix Asphalt method [refer with: Fig. 5]. In this study, the effect of the use of natural zeolite in the mixture of polymer modified asphalt concrete with hot mix asphalt method is analyzed based on the results of the Marshall test. Hot Mix Asphalt mixture using asphalt polymer elastomer with 0% zeolite, is a comparison mixture processed using temperature mixing and compaction temperatures based on viscosity test at 176°C and 162°C.

Table. 6 Effect of Natural Zeolite Content on Elastomer Polymer Asphalt Mixture

Characteristics of Mixed	Levels of Asphalt			Specifications
	0%	1%	3%	
Levels of Optimum Asphalt(%)	5.80	5.86	5.95	-
Density (t / m 3)	2.383	2.372	2.340	-
VMA (%)	15.5	15.8	17.1	Min.15
VIM Marshall (%)	3.1	3.70	4.0	3.0-5.0
VFB (%)	79.87	76.81	69.48	Min.65
Stability (Kg)	1551.2	1555.3	1507.7	Min.1000
Melting (mm)	4.74	4.95	5.04	Min.3
Marshall Quotient (kg / mm)	327.2	314.3	303.5	Min.300

VMA value, VIM, VFB, flow increased with increasing levels of natural zeolite [refer with: Table.6]. The increase that occurred not too significant. Overall characteristics of the mix, with levels of natural zeolite 1%, 2% and 3% in the mixture of polymer modified asphalt concrete meets specifications. Stability with the greatest value is in the mix with the zeolite content of 1%. Marshall to influence levels of natural zeolite as an additive mixture of polymer modified asphalt concrete.

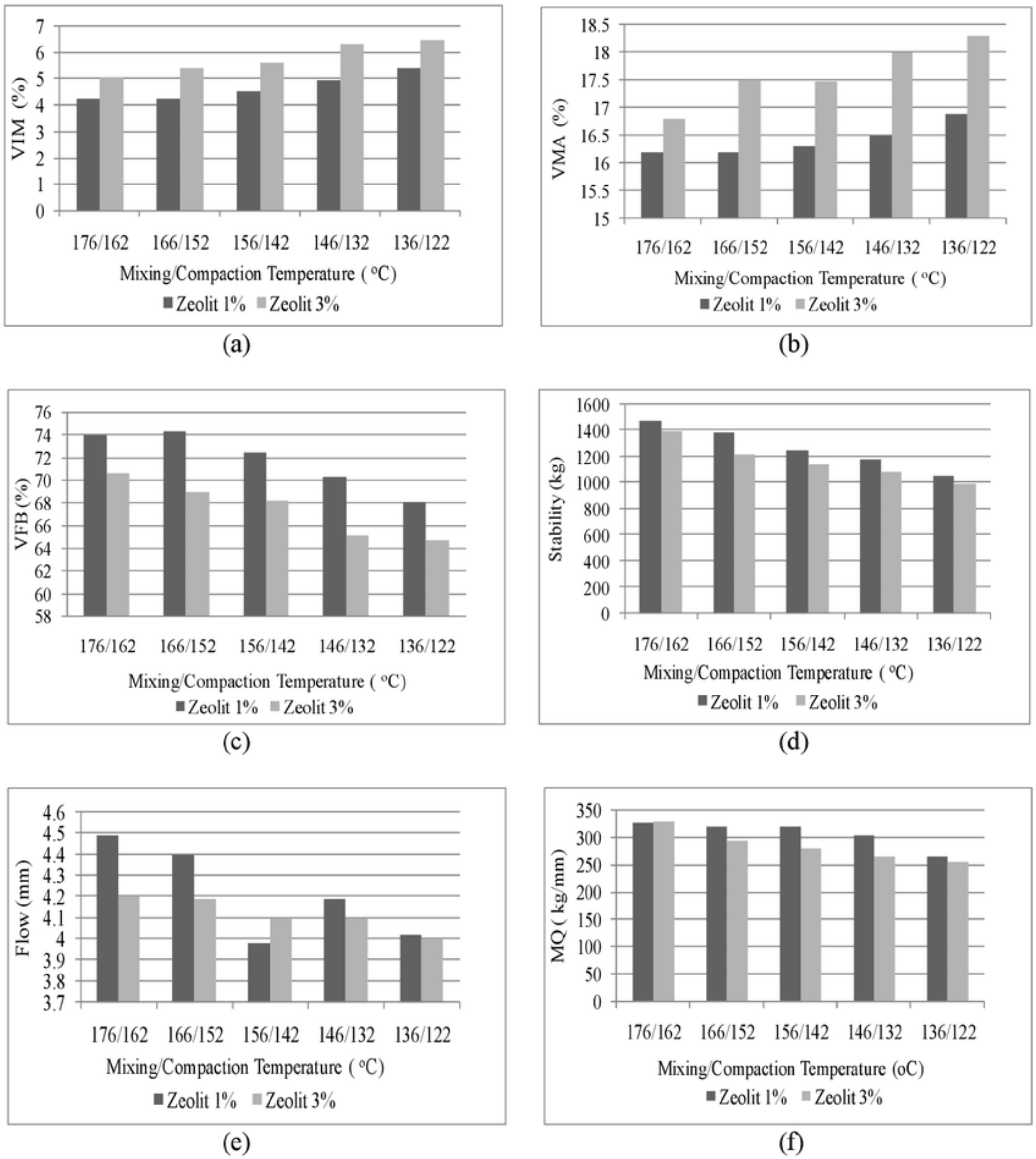

Figure.4 Effect of Natural Zeolite Levels 1% and 3% Against Concrete Modified Asphalt Polimers Mixture Characteristics at Various Mixing/Compaction Temperatures

Visible effect of natural zeolite levels 1% and 3% as an additive in asphalt concrete mixtures modified polymers that are processed using Warm Mix Asphalt [refer with: Fig.4]. Relationship between the density of the mixing and compaction temperatures, reflecting the declining trend line density increased levels of zeolite and decreasing temperature. This is evident from the nature of the density of the mixture with the added ingredient of natural zeolite which is almost equal to the density of the mixture without the added ingredient of natural zeolite. Relationship voids in mineral aggregate (VMA), VFB, Flow and Marshall Quotient with temperature [refer with: Fig. 4b, Fig. 4c, Fig. 4e, Fig. 4f] showing the temperature range of mixing / compaction temperatures of 166°C / 152°C - 136°C / 142°C for asphalt mixtures containing zeolite content of 1% and 3% can meet the specifications [2]. As for the relationship void in mix (VIM) with temperature [refer with: Fig. 4a],

the value of the test results obtained by the VIM can be filled with a mixture of 1% zeolite content up to temperatures of 146°C / 132°C. While the value of VIM at 3% zeolite content, no VIM value that meets the specifications. This indicates that the polymer asphalt mixture with zeolite content of 1% can be mixed at 30°C lower than normal temperatures. Relationship stability against temperature [refer with: Fig. 4d] shows that the mixture with 1% zeolite can be filled up to 30°C temperature lower than the temperature of mixing and compaction temperatures Hot Mix Asphalt. As for the mixture of 3% zeolite content only met up at a temperature of 156°C / 142°C.
From the flow chart shown that the flow in the mixture of polymer modified asphalt concrete containing levels of 1% and 3% zeolite has a temperature range of mixing and compaction temperatures are the same, which meets the requirements of the minimum melting. The use of natural zeolite materials added Bayat, the type of mineral modernit on the asphalt mixture using elastomeric polymer asphalt binder, when viewed from the decrease in temperature that has been done, can reduce the temperature of mixing / compaction at 30°C, the equivalent of warm mix asphalt binder using conventional synthetic zeolites material added.

5. Conclusions

Based on the results of testing the effect of natural zeolite as an additive in asphalt concrete mixtures modified elastomeric polymer, it can be deduced:

1) Activation method plays an important role in order to optimize the water content contained in the natural zeolite. Chemical activation method is a method of efficient processing of natural zeolite and can effectively improve the absorption of the water content of 18.99% moisture content mendekatai synthetic zeolites ± 20%. 2)
2) Levels of natural zeolite minerals modernit Bayat types that can be used as additives in polymer modified asphalt mix concrete were mixed and compacted using warm Mix Asphalt is a zeolite content of 1% of the weight of the mixture.
3) 1% natural zeolite Bayat mineral modernit can lower the temperature of the mixing / compaction temperature of 30 °C lower than hot mix asphalt, which is from 146°C to 176°C into a mixing temperature of 162 °C and 132 °C to be a compaction temperature.

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